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MOSSES FROM ROVNO AMBER (UKRAINE)

МХИ ИЗ РОВЕНСКОГО ЯНТАРЯ (УКРАИНА)

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Abstract

Seven moss genera are revealed in Eocene amber from Rovno (Ukraine). Some species are similar to those from Baltic amber (*Hypnodontopsis mexicana*, *H. piliferum, Ctenidium capillifolium, Tristichella glabrescens*), while others can be referred to *Sematophyllites* from Baltic amber, but not identical to any of the described species of this genus. *Neckerites* gen. nov. is described to accommodate plants very similar to the modern Neckeraceae, although even the genus cannot be indicated for sure. *Palamocladium fossile* sp. nov. and *Isopterygiopsis minutirameum* represent new genera to Eocenic amber flora. One moss fragment with short and broad leaves is left unnamed, as its diagnostic characters are too poorly seen.

Резюме

Семь родов мхов найдены в янтаре эпохи Эоцена из Ровно (Украина). Некоторые виды сходны с ранее описанными из балтийских янтарей (*Hypnodontopsis mexicana*, *H. piliferum, Ctenidium capillifolium, Tristichella glabrescens*), в то время как другие можно отнести к роду *Sematophyllites* из балтийских янтарей, однако они не похожи ни на один из описанных видов этого рода. Описан род *Neckerites* gen. nov., включающий растения, очень похожие на современных представителей семейства Neckeraceae, хотя невозможно уверенно указать современный род, с которым они сходны. *Palamocladium fossile* sp. nov. и *Isopterygiopsis minutirameum* представляют новые роды для янтаря Эоцена. Один фрагмент мха с короткими и широкими листьями остался не описанным, поскольку его диагностические признаки плохо выявляются.

KEYWORDS: fossil, mosses, amber, Rovno Province, Ukraine, Tertiary, Eocene

INTRODUCTION

Amber is the main source of information on Tertiary mosses, and many of them were found in Baltic and Saxonian amber in Europe and Dominical amber in Central America (Frahm, 2010; Frahm & Newton, 2005). Rovno amber from Ukraine has never been studied before for bryophytes. In the course of insect study, the latter author accumulated a number of moss and liverwort specimens; the mosses are described in the present paper.

Rovno amber is found predominantly in the lower part of Mezhygorje Formation (Lower Oligocene). Amber was also reported from Obukhov Formation (Upper Eocene), but this has not been confirmed in the recent stratigraphic studies (Perkovsky et al., 2010).

As the evidence from insect fauna indicates, the age of the Rovno ambers is identical to that of Baltic amber (Kosmowska-Ceranowicz, 1999; Perkovsky et al., 2003) and corresponding to Upper Eocene (see Perkovsky et al., 2007, 2010; Aleksandrova & Zaporozhets, 2008a, 2008b).

Amber specimens were excavated from Pugach quarry (Klesov), excepting three amber pieces with inventory numbers UA-2325, UA-1972 and UA-

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1965, which origin is somewhat indefinite: either the same Klesov (Pugach) or Dubrovitsa (Vol'noje) quarries (Perkovsky et al., 2010).

GENERAL COMMENTS

Mosses of Baltic amber are known since the mid-XIX century (Göppert, 1853), and recently this scattered information has been summarized by Frahm (2010). About 50 out of 65 species known up to now from Eocene throughout the world belong to the Baltic area. However this number, as well as plant naming, need a certain comment. Many mosses are pleurocarpous, and the available characters are far from sufficient for certain identification. Even contemporary pleurocarps available for study of peristomes, alar cells, branch primordia, stem anatomy, etc., are not always well attributed to one or another family. Molecular phylogenetic analyses have recently found an incongruence with the traditional system and have changed the generic and familial placement of many species (e.g., Shaw et al., 2003; Ignatov et al., 2007). Many of those structures are either unclear or cannot be studied in amber specimens at all, so the arguments for the referring of a specimen to the given genus are often quite weak and an alternative ideas cannot be rejected. Therefore, for a number of taxa discussed below, we will discuss other possible plants affinities, no matter how imperfect and easily contestable in turn they are.

In this situation, we are trying to use names which are utmost consistent with the previously published material on Eocenic and Oligocenic European amber. Such approach allows to compare Rovno amber with Baltic and Saxonian ones leastwise.

Thus the scheme of the foregoing species description is as follows: (1) comparison with previously published amber mosses, explaining its generic or specific placement; (2) plant description; (3) material description; (4) possible alternative affinity.

* * *

In addition, a remark on a dimensional characteristic of amber mosses would be necessary. At least some (and likely most) of the collections preserved in amber represent epiphytic mosses sunk in resin of amber tree, often called *Pinus succinifera,* which obviously do not belong to *Pinus* and is apparently a species of *Pseudolarix* (Anderson & LePage, 1996). The growth on trunks is often making mosses, especially some pleurocarps, quite tiny, so the shoot tips in amber have dimensional values at the lowest possible level of contemporary mosses. They might look too small, compared with "normal" sizes from the modern floras that provide average sizes of relatively well-developed plants.

* * *

All specimens are housed in the amber collection of Schmalhausen Institute of Zoology in Kiev (SIZK). Ants mentioned as syninclusions for moss specimens were determined by G.M. Dlussky, spider by K.Yu. Eskov, most mites by A.A Khaustov and E.A. Sidorchuk, other syninclusions by second author.

TAXONOMY

Genus **Hypnodontopsis** (extant, family Rhachitheciaceae)

Description: Plants small. Stem short, erect, densely foliate. Leaves small proximally, crowded distally, erect to somewhat spreading, lanceolate, obtuse to acute, margin entire, flat to slightly recurved, not bordered; costa strong, disappearing shortly below leaf apex, in lower part 1/5–1/7 of leaf width. Laminal cells more or less isodiametric, 8-10 μm, in longitudinal rows, papillose with low rounded single papillae, in lower 1/6 part of leaf rectangular.

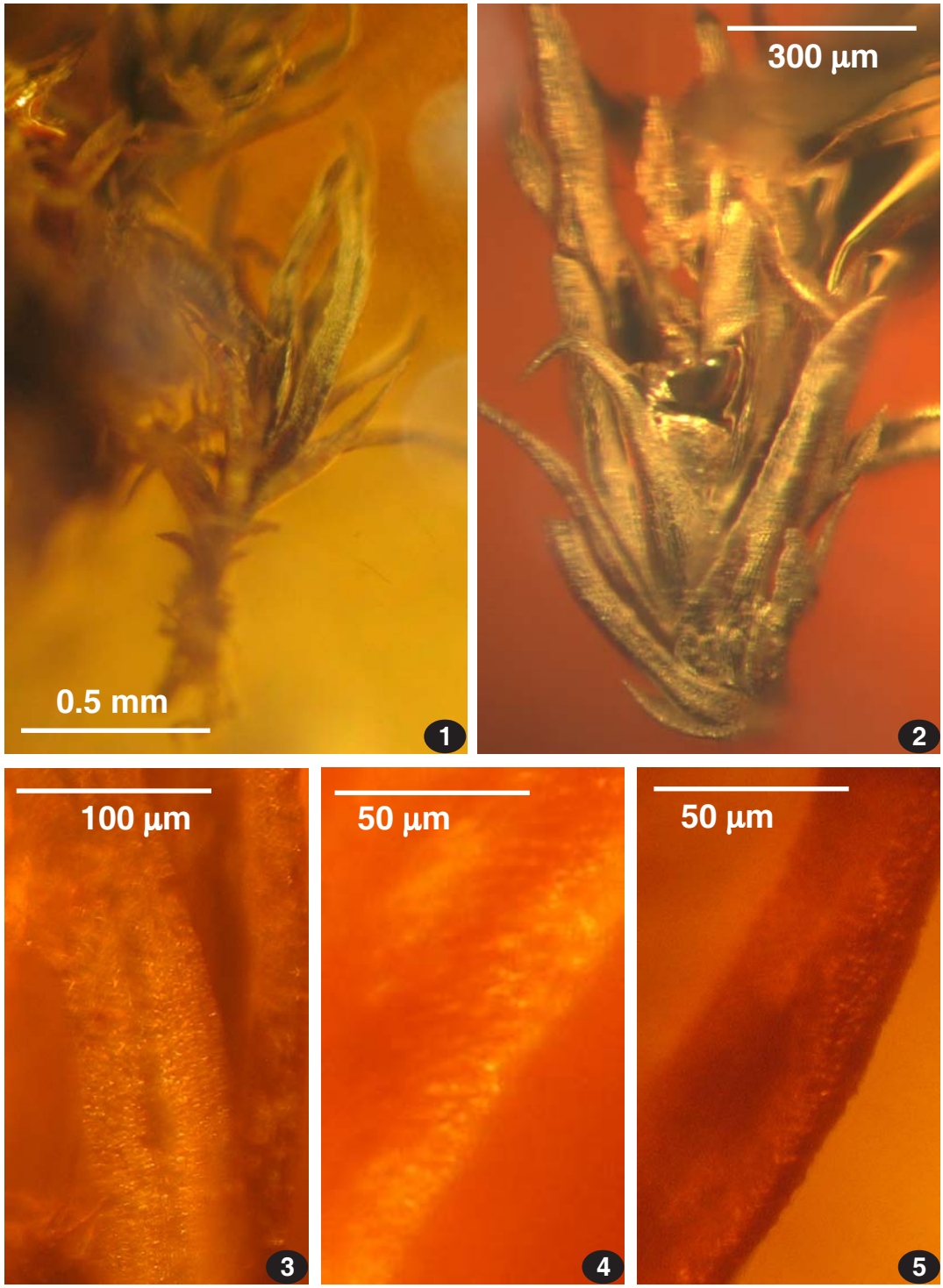
Type species: *Hypnodontopsis apiculatus* Z. Iwats. & Nog. (Japan).

The small acrocarpus mosses referred to this genus commonly occur in Baltic amber. They are classified by Frahm (2010) into 4 species, and two of them are known with sporophytes in Baltic amber.

1. **Hypnodontopsis mexicana** (Thér.) H. Rob. [extant, Mexico] (Figs. 1-5).

Systematic placement: Plants identified by comparison with illustrations of *H. mexicana* (Frahm, 2010: Fig. 68-69), drawing of the type of *H. conferta* (*Muscites confertus*) (Frahm, 2010: Fig. 67), and description of this modern species in the "Flora of Mexico" (Sharp et al., 1994).

Description: Plants with leaves up to 2 mm high. Stem short, apparently erect, densely foli-



Figs. 1-5. *Hypnodontopsis mexicana* (Thér.) H. Rob. (1 – from SIZK-K-3859; 2-5 – from SIZK-UA-2325): 1–2 – habit; 3-5 – leaves, allowing rough evaluation of cell size and papillose cell surface (better observed at folds, e.g. in 5). Elongate lower cells are apparent in some leaves in 2.

Fig. 6. *Hypnodontopsis pilifer* J.-P. Frahm (from SIZK-K-5943): habit.

ate. Leaves small proximally, crowded distally, erect, 0.7-1.2×0.1-0.2 mm (in the middle often 0.1-0.15 mm wide), shortly acute and blunt at apex, margin entire, flat to slightly recurved, not bordered; costa strong, ending near leaf apex, in lower part constituting ca. 1/5 of leaf width, slightly projected on dorsal side of leaf, grooved on ventral side of leaf. Laminal cells more or less isodiametric, 8-10 µm, in longitudinal rows (6-8 on each side of costa), papillose with low rounded single papillae, in lower 1/6 part of leaf rectangular.

Specimens examined: (1) Klesov. Rovno amber. Late Eocene. SIZK-UA-2325 [syninclusions: UA-2324 Scraptiidae (Coleoptera), Sciaridae, Hymenoptera, 2 Acari; UA-2325: 2Coleoptera (Leiodidae, Staphylinidae), 2 workers of *Pseudolasius boreus* Wheeler (Formicidae), Isopoda, Dolichopodidae]; (2) Klesov. Rovno amber. Late Eocene. SIZK-K-3859.

Material: The moss is known from two pieces of amber that include 2 (Fig. 1) and 1 (Fig. 2) sterile plants. Areolation is seen in few places, although cell width can be measured in many places (Figs. 2-3). Papillosity is difficult to observe in frontal views (Fig. 4), although a rough leaf outline (Fig. 5) is readily observable.

Comparison: Although many specimens from Baltic amber referred to this species have peristomes, the fine structure of the latter has never been analyzed in details. Therefore the affinity with the Rhachiteciaceae (where the extant *Hypnodontopsis* is placed) is not proved so far. Both the sporophyte and gametophytes are similar also to some Rhabdoweisiaceae (Dicranaceae p.p.), especially genera around *Cynodontium* – *Cnestrum* – *Oreas*, although these genera have usually somewhat larger plants.

2. **Hypnodontopsis pilifer** J.-P. Frahm (Fig. 6).

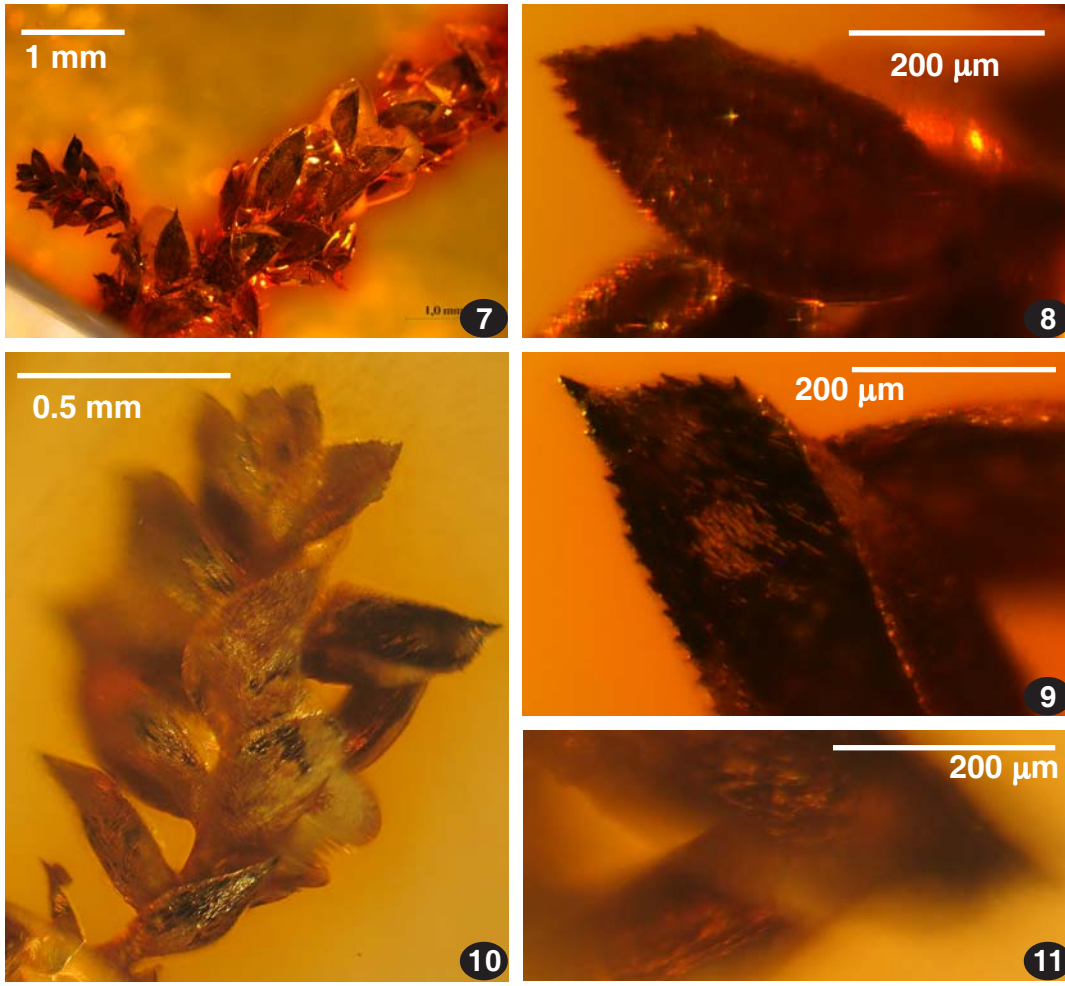
Systematic placement: Compared with the illustration of the type: Frahm 2010, Fig. 74.

Description: Stem short, apparently erect, densely foliate. Leaves crowded distally, erect, up to 1.0×0.2 mm, lanceolate below, gradually tapered to apex and with thin attenuate hair-point (ca. 200 µm long), margin entire, flat to slightly recurved, not bordered; costa strong, apparently excurrent, in lower part constituting no less than 1/7 of leaf width, slightly projected on dorsal side of leaf. Laminal cells more or less isodiametric, ca. 10 µm, in longitudinal rows (ca. 10 on each side of costa), papillose.

Specimen examined: Klesov. Rovno amber. Late Eocene. SIZK-K-5943 [syninclusions: K-5942 (Leiodidae); K-5943: worker of Ctenobethylus goepperti (Mayr) (Formicidae), Glaesacarus rhombeus (Glaesacaridae)].

Material: This species is represented by one fragment of upper shoot with four leaves. It is impossible to say whether leaf hair points are hyaline or not. Cell size and papillosity are well observable.

Comparison: Comparatively with *H. mexicana*, the ends of leaves are more gradually tapered. Common characters with *H. mexicana* include small size of plants, similar foliage, laminal cell size and papillosity. *Hypnodontopsis fossilis* J.-P. Frahm has a thin leaf apical part and is very similar to our material of *H. pilifer*, but leaves in that species are much narrower.



Figs. 7-11. *Neckerites pusillus* sp.nov. (from SIZK-UA-1972): 7 – stem with one branch; 8-9 – upper part of branch leaves, showing coarsely serrate leaf margin; 10 – branch; 11 – branch leaf, allowing rough evaluation of median laminal cells.

Genus **Neckerites** gen. nov. [form-genus, family Neckeraceae]

Description: Stem creeping, branched, branches deviating at about right angle; foliage dense, terete to subcomplanate. Leaves erect to patent, ovate, shortly acute; long single costa absent; margin coarsely serrate above, serrulate in mid-leaf; laminal cells elongate; branch leaves smaller than stem leaves, otherwise similar.

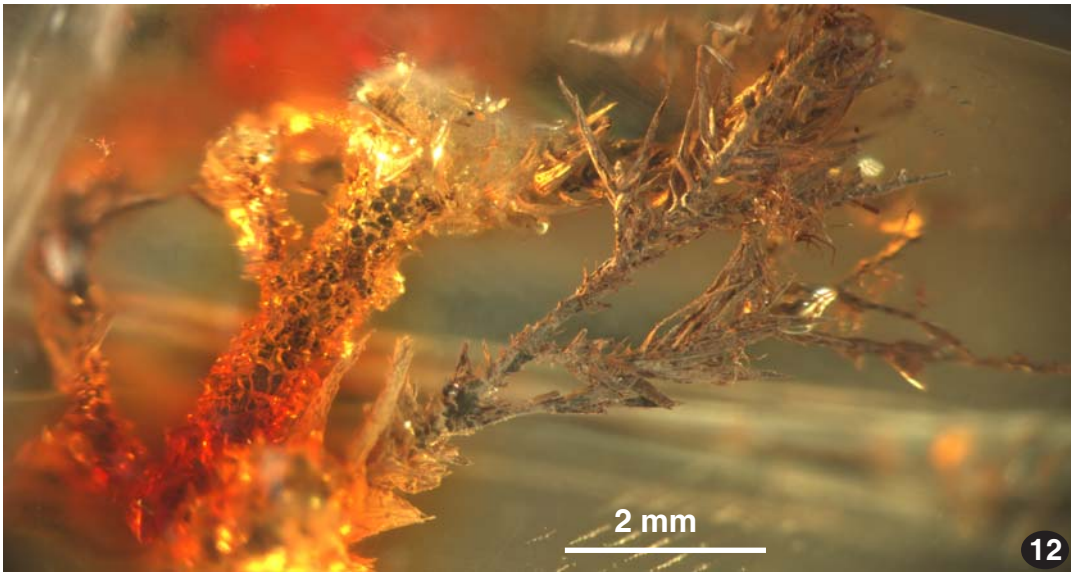
Ethymology: a moss similar to moss genus *Neckera* Hedw. s. ampl.

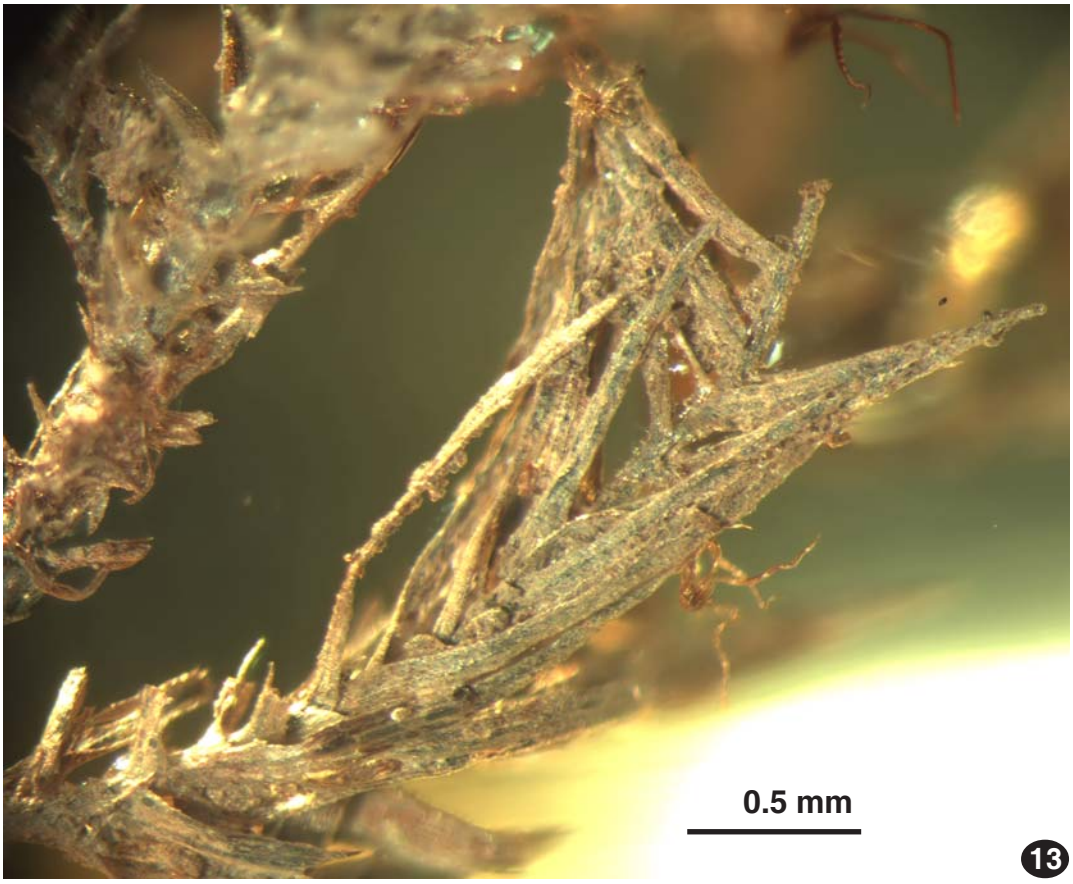
Type species: *Neckerites pusillus* sp.nov.

Plant is characterized by broad ovate leaves, coarse distal margin serration and elongate laminal cells. In its overall appearance this moss is similar to some amber specimens of *Trachycystis*, but the latter genus has isodiametric laminal cells.

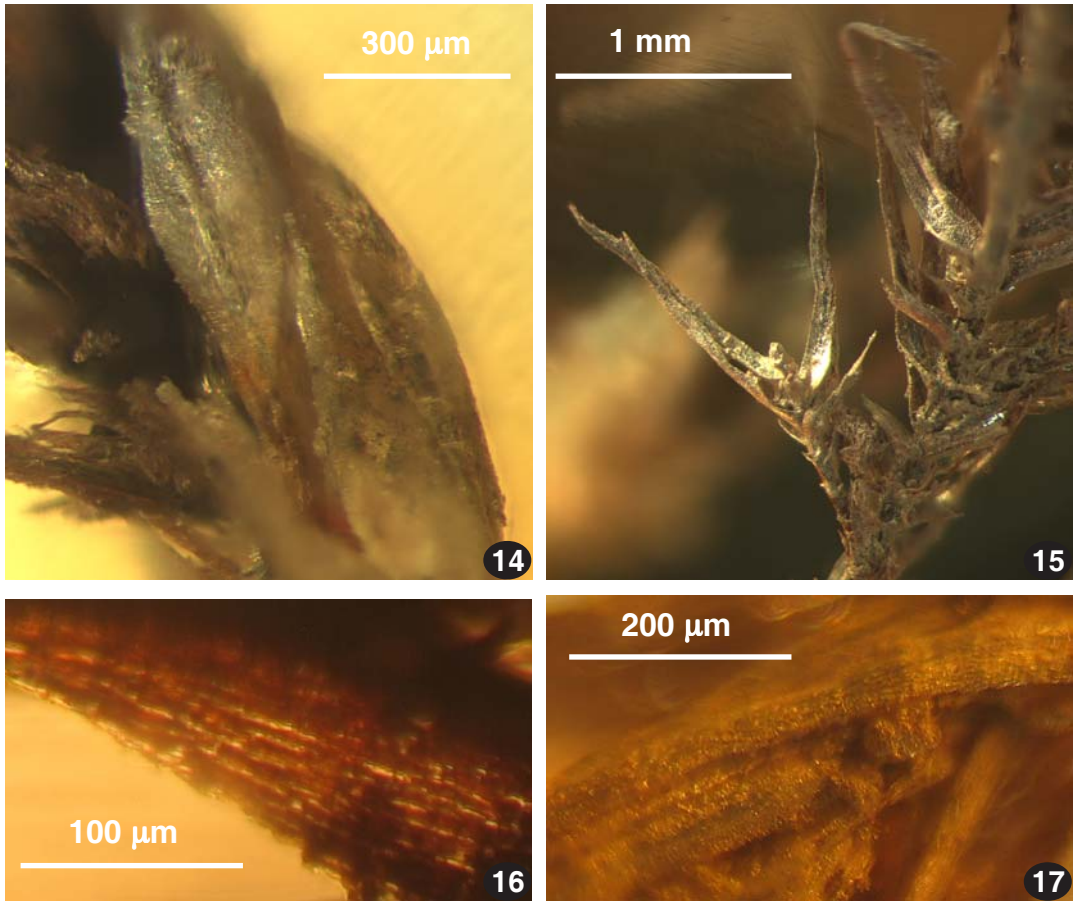
The name refers to the genus *Neckera*, but some complicated parallelisms in this family (cf. Olsson et al., 2011) suggested it better to consider various genera with broad leaves in the family: *Neckera, Exertotheca, Forsstroemia, Thamnobryum,* etc. Therefore we suggest here the indefinite formal name to exclude the possible subsequent statement that one of those genera has already appeared in early Tertuary.

The family is widespread now in the temperate to subtropical climate, which was in Eocene time in Europe, and this corresponds (among many other evidences) with the finding in amber





Figs. 12-13. *Palamocladium fossile* sp.nov. (from SIZK-K-10050-F): 12-13 – stem with branches.



Figs. 14-17. *Palamocladium fossile* sp.nov. (from SIZK-K-10050-F): 14 – relatively large stem leaf; 15 – branches with leaves (in leaves of left branch serrate leaf margin is visible); 16 – part of stem leaf, showing elongate cells at 1/2–1/3 the leaf length; 17 – part of stem leaves, showing elongate median leaf cells.

of *Trachycystis, Nipponolejeunea, Hypnodontopsis*, etc. So it is rather strange that the representatives of the Neckeraceae have not been found in Baltic amber earlier.

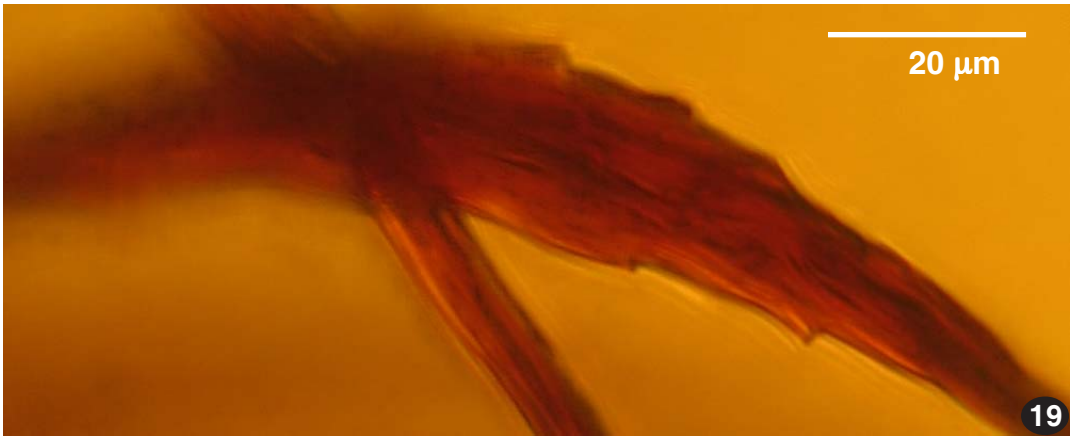
Neckerites pusillus sp. nov. (Figs. 7-11).

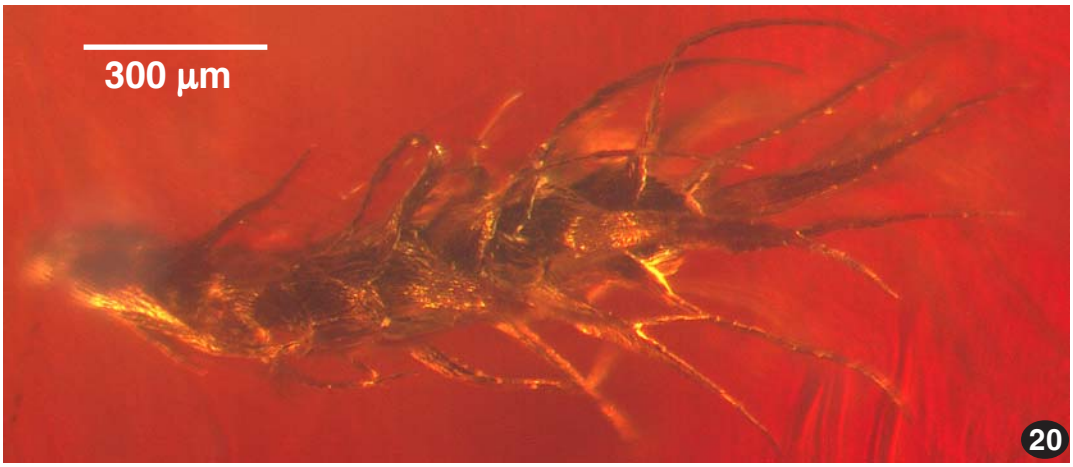
Holotype: Rovno amber. Late Eocene. SIZK-UA-1972.

Description: Stem >5 mm long, sparsely branched, with branches deviating at ca. 90°, terete to subcomplanately densely foliate. Leaves erect to somewhat spreading, 1 mm long, 0.45 mm wide, ovate, acute, slightly concave; margin plane, not bordered, coarsely serrate distally, serrulate in the middle; long single costa absent. Branch leaves similar, but smaller, 0.6 mm long, 0.2 mm wide; laminal cells at 3/4 the leaf length up to 15 µm long and 6-7 µm wide; towards leaf base and in proximal branch leaves cells are more elongate, to 3-4:1.

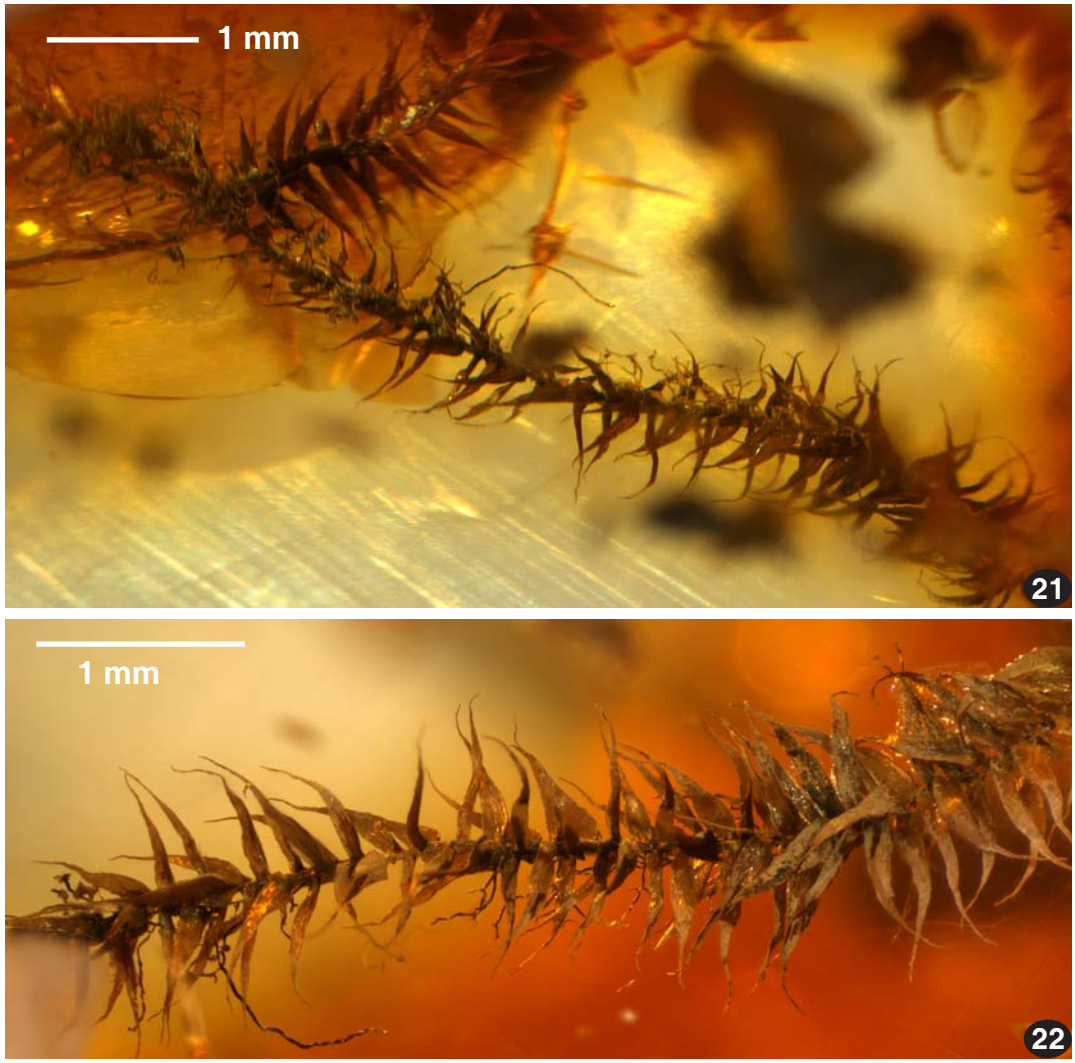
Material: This genus and species is represented by only one small shoot (Fig. 7) with one short branch (Figs. 7, 10). Marginal teeth are coarse and multicellular (Figs. 8-9). Costa was not seen, although in some branch leaves cell structure was apparent almost throughout the leaf (Figs. 9, 11). Stem leaves were not so clearly visible, and cell structure only at places was ‘subdiscernible’, not differing from the pattern more or less apparent in branch leaves.

Comparison: Among mosses from Baltic amber, the most similar to *Neckerites pusillus* are probably fragments referred by Frahm (2010) to *Symphiodon sp*. Both have broad leaves, compla-





Figs. 18-20. *Ctenidium capillifolium* (Mitt.) Broth. (18-19 – from SIZK-UA-1965; 20 – from SIZK-K-25469): 18 & 20 – shoot (apparently branch) tips, showing ecostate falcate-secund leaves with elongate cells; 19 – distal part of leaf, showing serrate leaf margin.



Figs. 21-22. *Isopterygium minutirameum* (Müll. Hal.) A. Jaeger (from SIZK-K-3178): stems with spreading leaves and branched rhizoids.

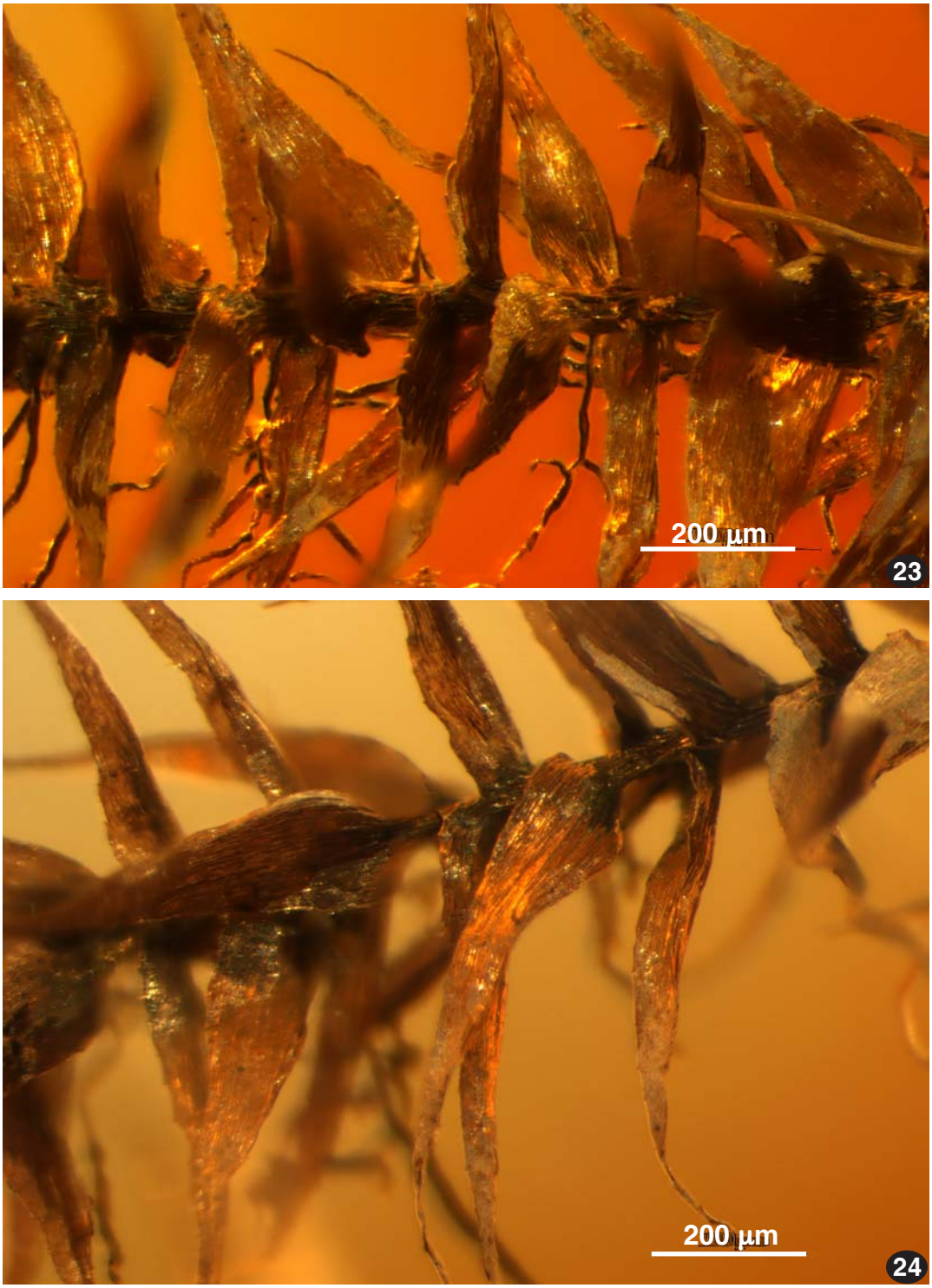
nate to subcomplanate foliage, shortly acute leaves. However, the leaves of *Symphyodon* are fairly remote and their margin is regularly serrate in upper 3/4, without coarse multicellular teeth near leaf apex that are so characteristic of the modern species of the Neckeraceae.

Genus **Palamocladium** Müll. Hal. [extant, family Brachytheciaceae]

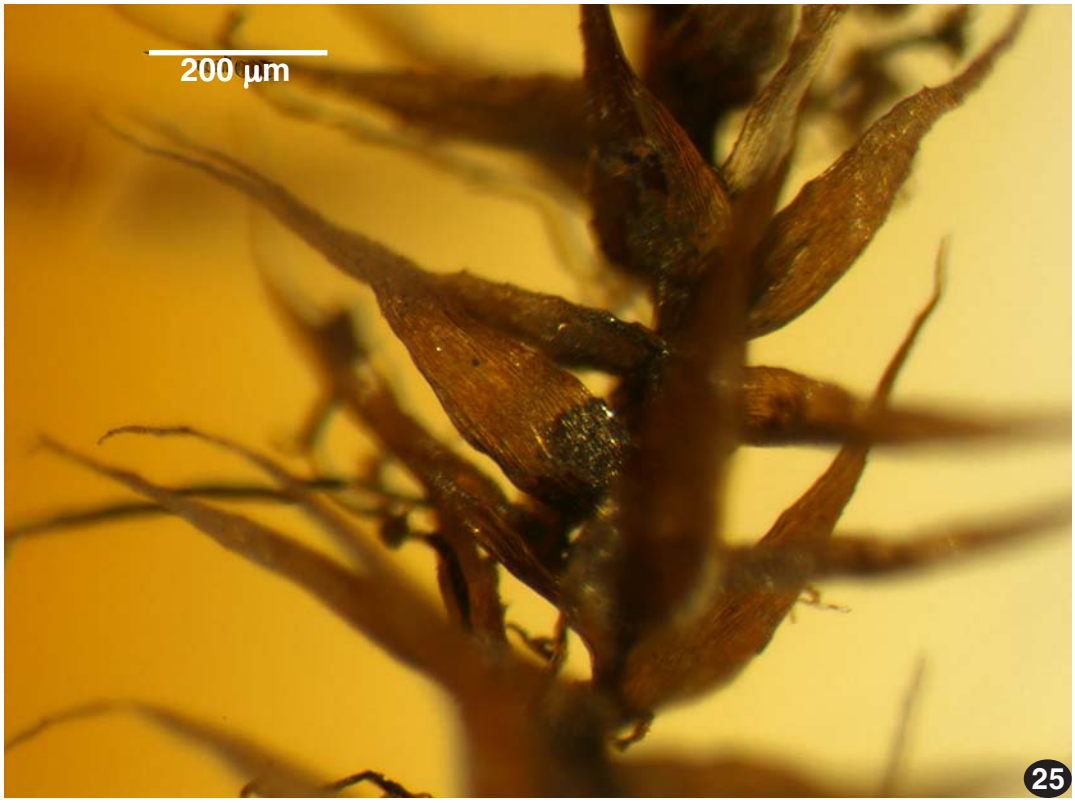
Description: Pleurocarpous moss with more or less regularly branched stem, branches deviating at acute angle; foliage terete, dense, branch foliage similar to that of stem. Leaves erect, lanceolate, gradually long-acuminate, somewhat concave and plicate, costa single and long, disappearing in narrow part of acumen; margin serrulate; laminal cells elongate, usually 4-8:1.

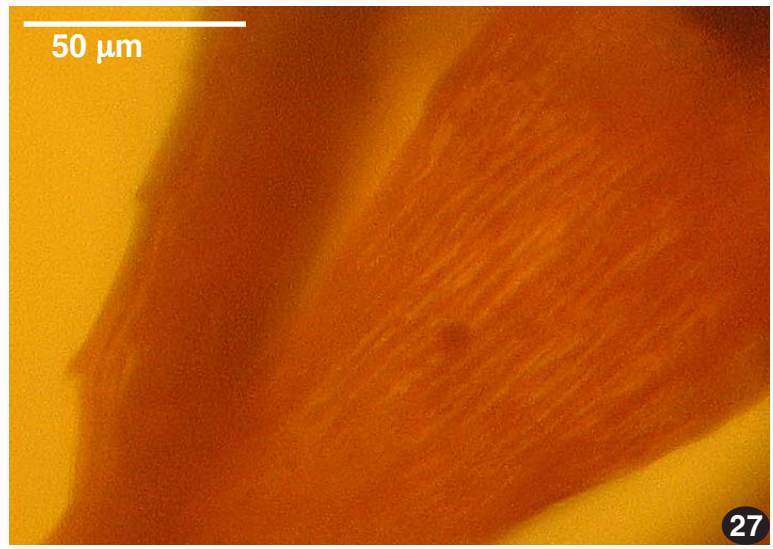
Type: *Palamocladium leskeoides* (Hook.) Britt. (the species understood *sensu stricto* occurs in tropical and subtropical America, while *sensu lato* it has a pantropical distribution).

Although the present-day collection of *Palamocladium* can usually be recognized by habit, its identification relies mostly on characters of plant size, texture and color, unavailable in fossil state. Leaf characters observable in amber are not peculiar enough to separate it accurately from some species of the Amblystegiaceae (*Hygroam-*



Figs. 23-24. *Isopterygium minutirameum* (Müll. Hal.) A. Jaeger (from SIZK-K-3178): stems with leaves, showing lack of costa, serrulate margin and rhizoids sitting on stem below leaf insertion (or at least definitely not axillary).





Figs. 25-27. *Isopterygium minutirameum* (Müll. Hal.) A. Jaeger (from SIZK-K-3178): 25 – stems with spreading leaves; 26-27 – leaves, showing details of areolation.

blystegium) or the Echinodiaceae (*Echinodium*). Our choice of *Palamocaldium* is based primarily on its plicate leaves, most characteristic of the Brachytheciaceae.

Other Brachytheciaceae, e.g., *Sciuro-hypnum populeum* (Hedw.) Ignatov & Huttunen, *Rhynchostegiella spp*. fit the specimen under discussion by plant size, but their leaves are not so clearly plicate.

In modern flora, *Palamocladium* is generally a pantropical genus with a northern distribution limit in the southeastern U.S.A., Japan and the Caucasus.

The plant from Rovno amber cannot be referred to any of modern species because of the absence of characters that may indicate closer affinity to one of them. Thus we describe the fossil plants as a separate species to prevent any linking of modern species with the early Tertiary.

Palamocladium fossile sp. nov. (Figs. 12-17).

Holotype: Klesov. Rovno amber. Late Eocene. SIZK-K-10050-F [syninclusions: K-24678 (Psychodidae, Chironomidae)]

Description: Stem >1 cm long, sparsely branched, with branches deviating at ca. 30°, densely terete foliate, with clusters of brown branched rhizoids. Leaves erect, 1.6 mm long, 0.4 mm wide, narrowly lanceolate, gradually acuminate, slightly concave and plicate; margin plane, not bordered, serrulate distally, entire or subentire proximally; costa distinct up to acumen, ca. 40 μm wide. Branch leaves similar, but smaller, 0.8 mm long, ca. 0.25 mm wide; laminal cells up to 65 μm long and 6-8 μm wide.

Material: This species is known by two shoots (possibly from one plant) in one amber piece, one with several branches (Fig. 13), and several stem and branch leaves. Another shoot is less visible, but characterized by broader, better developed leaves (Fig. 14). Marginal serration is seen mostly in branch leaves (Fig. 15). Lamina areolation is apparent at places (Figs. 16-17).

Comparison: Frahm (2010) picture of Holt Fr-5 collection (Fig. 147, as unknown pleurocarpous moss) may represent the same species described here as *P. fossile*. *Echinodium* specimen from amber (Frahm, 2010: Fig. 75) has too dense foliage, shorter and dorsally prorate cells.

Genus **Ctenidium** (Schimp.) Mitt. [extant, family Ctenidiaceae]

Description: Pleurocarpous moss. Leaves falcate-secund, often with basal part more or less appressed, margin serrate to serrulate, strong single costa absent, laminal cells linear.

Type species: *Ctenidium molluscum* (Schimp.) Mitt. (*Hypnum molluscum* Hedw.), a species widespread in Holarctic.

This aforecited combination of characters occurs in many groups of pleurocarps, for example in many species of *Hypnum* s. ampl., and their separation characters include alar cells, proximal branch leaves, perichaetial leaves, sporophytic characters, etc.

The main reason for the placement of a number of specimens from Rovno amber in *Ctenidium* is that they are superficially quite similar to the plants from Baltic amber referred to *C. capillifolium* (Frahm, 2010: Figs 135, 136, 139). Our identification cannot be considered as very well based, because Rovno specimens are represented by two small shoot fragments only.

Ctenidium capillifolium (Mitt.) Broth. (extant, Japan, Korea, China) (Figs. 18-20).

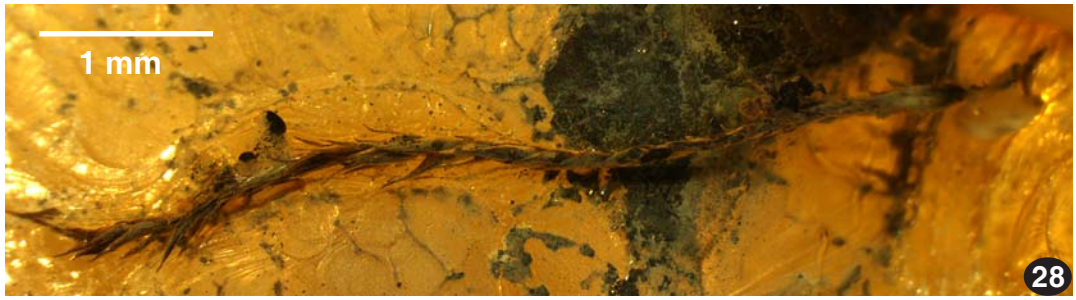
Systematic placement: Our two specimens appear within a variation as is described and illustrated by Frahm (2010: Figs 135, 136, 139).

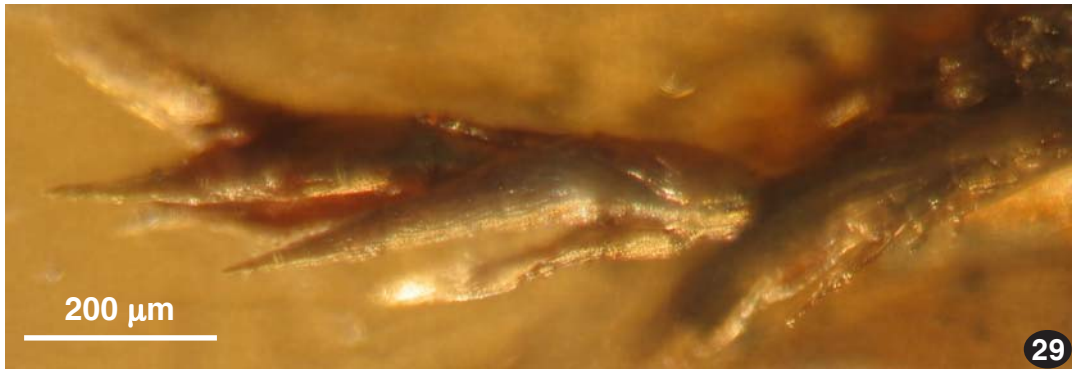
Description: Shoots >1.5 mm long, densely terete foliate; leaves shorter towards shoot base. Leaves erect proximally, falcate-secund distally, 0.5-0.7 mm long, 0.15 mm wide, ovate below, abruptly tapered to narrow acumen; margin plane, not bordered, serrate; long single costa absent. Laminal cells linear, 4-5 μm wide, and about 5-8 times longer than wide, towards the base somewhat shorter.

Specimens examined: (1) Rovno amber. Late Eocene. SIZK-UA-1965. (2) Klesov. Rovno amber. Late Eocene. SIZK-K-25469 [syninclusions: K-25468 Collembola (Symphypleona); K-25469 worker of *Ctenobethylus goepperti* (Mayr) (Formicidae), 2 ex. *Glaecarus rhombeus* (Glaesacaridae); Oribatei (Acari), 3 ex. Collembola (Symphypleona)].

Material: The species is represented by two upper shoot fragments, ca. 1.5 mm long (Figs. 18, 20). They represent likely a short branches, becase the leaves are decreasing in length towards their bases. The marginal serration (Fig. 19) and absence of long single costa (Fig. 20) is clearly seen in some leaves. Leaf bases and their areolation are not available for study.

Comparison: Despite a quite definite placement, it is difficult to refute alternative affinities with *Pylaisiadelpha* (Pylaisiadelphaceae), *Ectropothecium* (Pylaisiaceae), *Hypnum* (Hypnaceae), etc.





Figs. 28-29. *Sematophyllites subjulaceus* sp.n. (from SIZK-K-10013-F): 28-29 – stems with more or less erect-appressed leaves without costa.

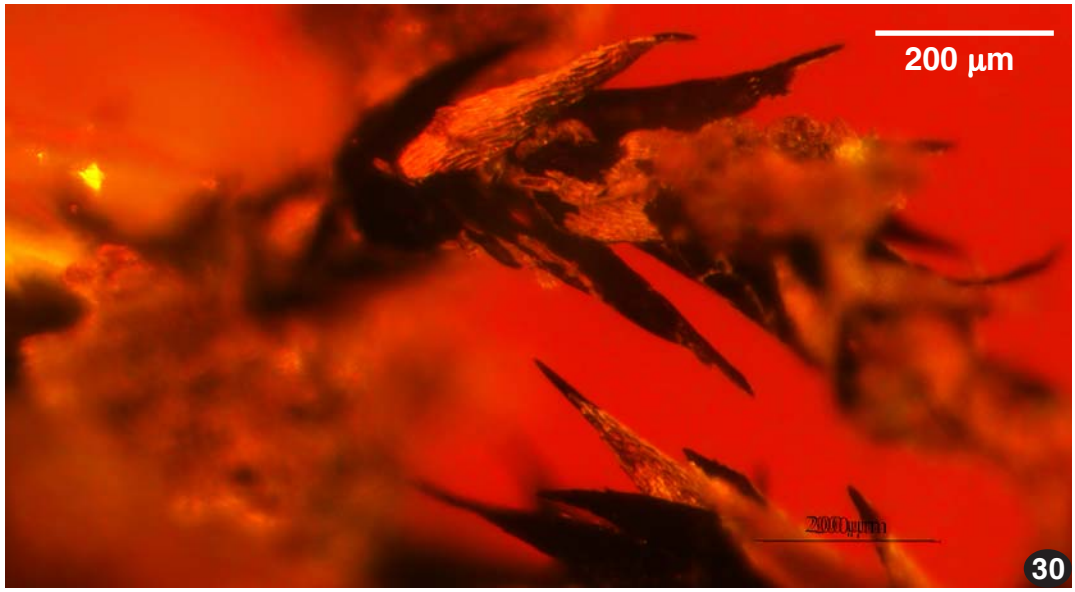
Genus **Isopterygium** Mitt. [extant, family Hypnaceae]

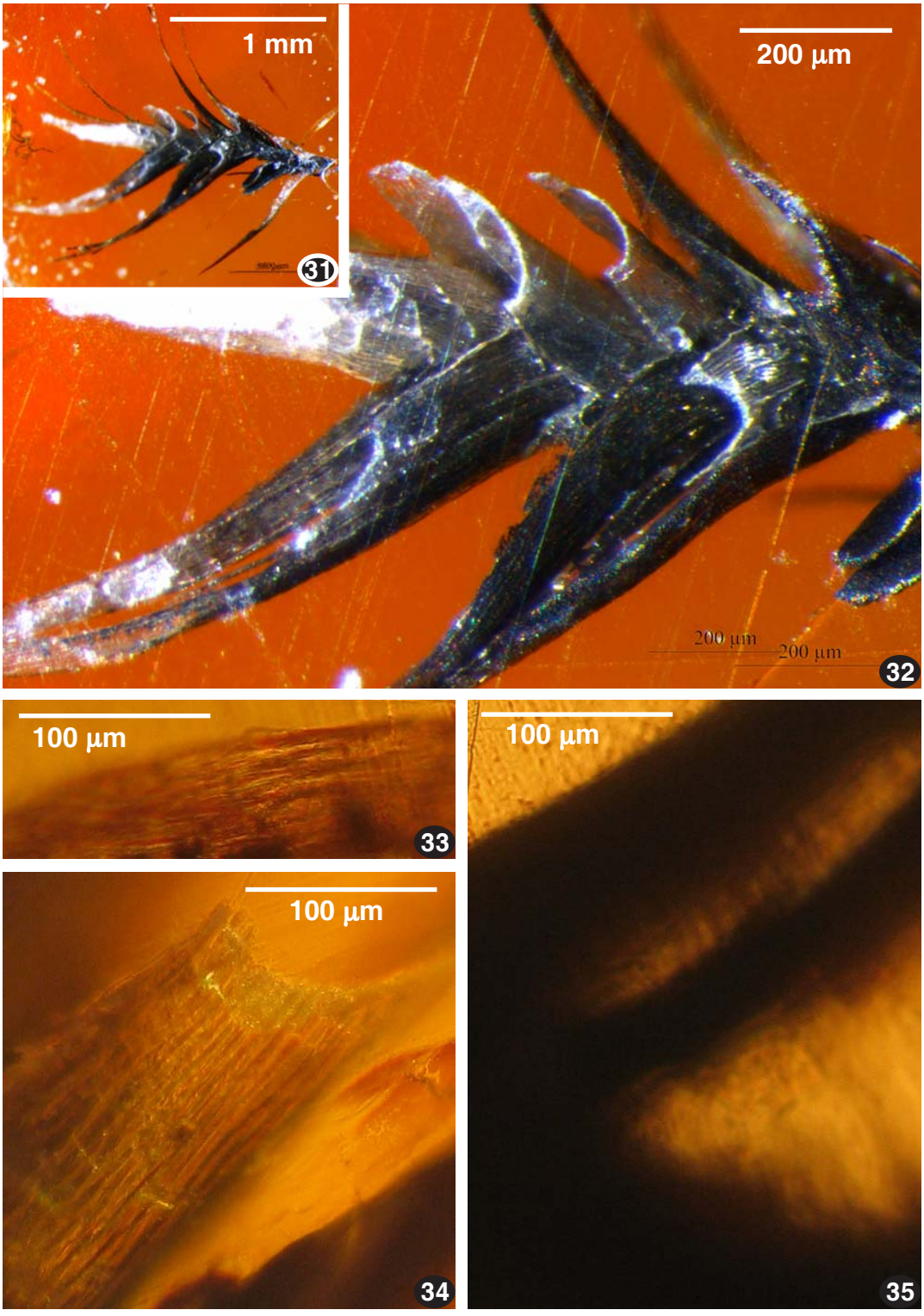
Description: Pleurocarpous moss. Plants small. Leaves straight, lanceolate, non-decurrent, margin serrulate, single costa absent, laminal cells linear.

Type species: *Isopterygium tenerum* (Sw.) Mitt. (widespread temperate to subtropical).

The mentioned combination of characters is not unique in pleurocarps, and moreover the genus is large and includes also medium-sized

Fig. 30. *Sematophyllites subjulaceus* sp.n. (from SIZK-K-3693): stems with erect ecostate leaves with elongate cells, similar to those in Rovno, SIZK-K-10013-F).





Figs. 31-35. *Tristichella glabrescens* Iwats. (from SIZK-K-6362): 31-32 – stems with erect-spreading tristichous leaves; 33-35 – laminal areolation in basal (34), midlle (33) and upper (35) parts of leaves.

plants. Many species have tendency to complanate foliage, but this is not a characteristic of all species of the genus. Poorly differentiated alar cells is an important feature of *Isopterygium*, but it is difficult to see in amber material, although long cells almost to base along leaf margin (Figs. 24-25) indicate that this is likely the case in the discussed Rovno amber specimen. Up to now *Isopterygium* has not been known in amber (cf. Frahm, 2010; Frahm & Newton, 2005).

Isopterygium minutirameum (Müll. Hal.) A. Jaeger [extant, pantropical] (Figs. 21-27).

Systematic placement: We apply the name of the extant species to amber specimens because it does not contradict any characters of the contemporary *Isopterygium minutirameum* and also because the species is a rather common epiphytic moss in tropical and subtopical areas in Asia, America and Africa.

Description: Stems >9 mm long, 35-40 μm wide, surface cells long-rectangular, 8-10 μm wide; straight to slightly flexuose, unbranched, terete, rather loosely foliate; leaves ca. 15 per 1 mm, multistichous; foliage rather even, leaves are slightly smaller towards shoot apices. Rhizoids scattered on stem in certain parts, solitary or clustered below leaf insertion, weakly branched, rather thick, up to 12 μm wide. Leaves spreading since their base at 50-100° from stem, straight to flexuose or indistinctly heteromallous, falcate distally, 0.6-0.85 mm long, 0.15-0.20 mm wide, lanceolate, gradually tapered to long narrow acumen, rather abruptly rounded to insertion, non decurrent, slightly concave due to insertion by V-shaped line to angle ca. 120°; margin plane, not bordered, serrate throughout; long single costa absent. Laminal cells linear, 70-80 μm long, 4-5 μm wide, shortly above leaf corner undifferentiated from laminal cells.

Specimen examined: Klesov. Rovno amber. Late Eocene. SIZK-K-3178 [syninclusion: Mycetophilidae].

Material: The species is represented by two shoot fragments in one piece of amber, 9 and 5 mm long (Fig. 21), the latter with part of stem leafless (likely due to decomposition prior fossilization). Leaves are clearly seen, allowing photographing and measuring laminal cells except for the very basal ones. However, the long cells shortly above the leaf corners indicate a very small and likely poorly differentiated alar group. The absence of decurrencies is apparent in several views (Figs. 23-24). Cell outlines are clear in many leaves (Figs. 23-27). Rhizoids occur in several zones, in other portions of stem they are lacking. Despite good views of stem in between leaves in many places no branch initials were seen.

Comparison: The present specimen is somewhat similar to *Sematophyllites serratus* (Göppert & Berrendt) J.-P. Frahm (Frahm, 2010: Figs. 112-114), but the latter species has most concave and more appressed basal part of leaves.

Genus **Sematophyllites** J.-P. Frahm (form-genus; family Sematophyllaceae; Baltic amber)

Description: Pleurocarpous moss. Foliage dense. Leaves erect, channeled-concave. Long single costa absent. Cells elongate to linear.

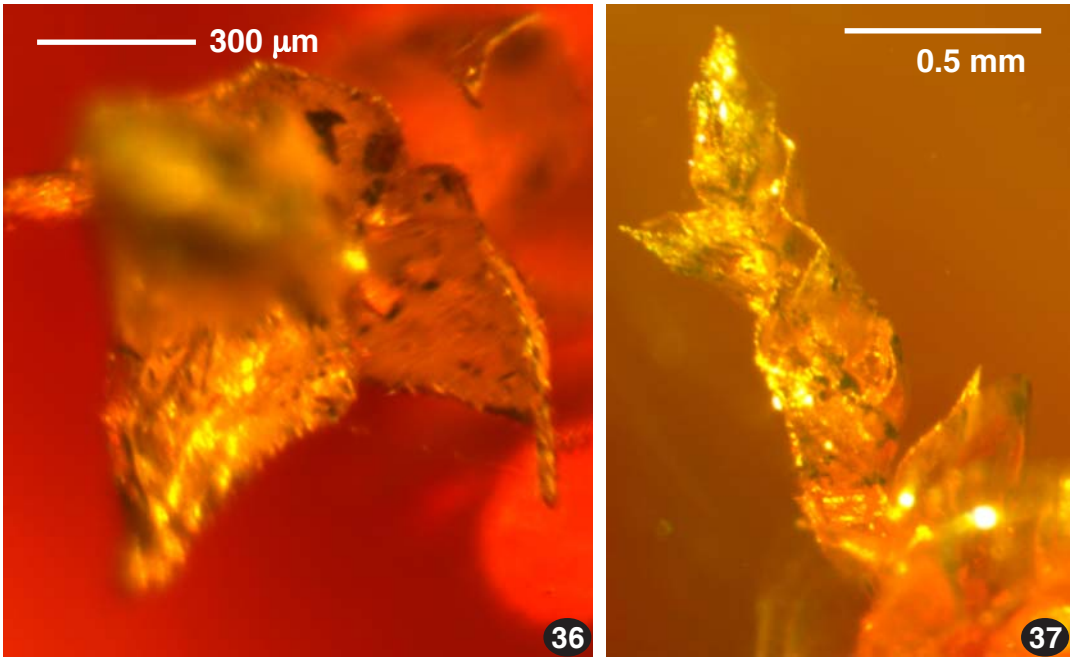
Type species: *Sematophyllites serratus* (Göpp. & Berendt) J.-P. Frahm.

As in case of *Neckerites*, the amber plants do not contradict modern mosses from many genera and even families (Habrodontaceae: *Habrodon*; Fabroniaceae: *Fabronia*; Plagiotheciaceae: *Orthothecium, Isopterygiopsis*; Hypnaceae: *Hypnum*; Pylaisiaceae: *Homomallium*; Pylaisiadelphaceae: *Brotherella*; Sematophyllaceae: *Acroporium*; Amblystegiaceae: *Serpoleskea*). Also, these amber plants may be interpreted as 'primary stems' with small leaves of 'Isobryalean' mosses with stoloniferous shoots (Neckeraceae, Lembophyllaceae, Leucodontaceae, etc.).

Hypnites would be probably a better name for pleurocarps without costa, by analogy with modern *Hypnum* having leaves always without long single costa. At the same time, in this genus a short and double costa is constantly present, but this character is totally outside of the present discussion as in amber material this character is almost always invisible. It should be noted that the type species of *Hypnites, H. haeringianus* Ettingsh. has a long single costa, being described in 1852, when the circumscription of *Hypnum* was quite different from the modern one.

Sematophyllites subjulaceius sp. nov. (Figs. 28-30).

Systematic placement: see discussion above, under genus.



Figs. 36-37. Unknown pleurocarpous moss [somewhat similar to *Brachythecium tortifolium* J.-P Frahm] (from SIZK-K-3606): same shoot from different views.

Description: Stems >6 mm long, 75 µm wide; slightly flexuose, unbranched, terete, rather densely foliate; leaves ca. 15 per 1 mm, multistichous; foliage more dense distally, while in proximal part leaves are smaller and relatively more remote, so stem is seen among leaves. Leaves erect, 0.3-0.5 mm long, ca. 0.1 mm wide, broadly lanceolate, gradually and broadly acuminate or narrowly acute, channeled-concave; margin serrulate; long single costa absent. Smaller leaves in proximal part of shoot appressed, 0.20×0.08 mm. Laminal cells in mid-leaf elongate-linear, 7-8 µm wide, 35-40 µm long, in upper leaves shorter and closer to leaf corners short, to 3:1.

Holotype: Klesov. Rovno amber. Late Eocene. SIZK-K-10013-F [syninclusions:K-2378 Mimetidae (Aranei); K-2379 Psocoptera;K-2380 2 ex. Parasitengona (Acari), K-2381 Collembola (Arthropleona); K-2382 Chironomidae (m), K-2383 4Acari (2 Oribatei, 1 Nanorchestidae);K-2384 Parasitengona (Acari); K-2385 Ceratoppia (Acari); K-2386 Collembola (Arthropleona);K-2387Chironomidae (2m), Parasitengona (Acari), Collembola (Arthropleona)#10013; Late Eocene (Figs. 28-29)].

Other specimen examined: Klesov. Rovno amber. Late Eocene. SIZK-K-3693 [syninclusion: Pseudoscorpiones].

Material: The species is represented in two pieces of amber, by one shoot fragment in each, 6 mm (Figs. 28-29) and 3 mm (Fig. 30) long. Plants are partly covered by mud, so some parts of holotype specimen are difficult to see, moreover this shoot is deeply inside amber, not allowing to apply a high miscroscope magnification. The second piece allows more clear view under high magnification, showing shorter cells near leaf apex, close to leaf corners and margin serration. As leaf and cell size and shape are the same as in the holotype, this second specimen is referred to the same species.

Comparison: *Sematophyllites subjulaceus* differs from other species of the genus in more concave erect leaves vs. rather plane and patent ones.

Genus **Tristichella** Dixon [extant, family Sematophyllaceae]

Description: Foliage dense, trifarious. Leaves erect-spreading, gently keeled. Long single costa absent. Cells elongate to linear.

Type species: *Tristichella spiculifera* Dixon (Malesia).

Trifarious leaves is a rare character in mosses, characteristic of all species of the Fontinalaceae, *Meesia triquetra*, and *Tristichella*. Two former taxa are hydro/hygrophytic, and thus less likely to be found in amber, while epiphytic modern *Tristichella* is commonly an epiphytic moss. In addition, the Fontinalaceae are usually large plants.

Tristichella glabrescens Iwats. [extant, Japan and Philippines] (Figs. 31-35).

Systematic placement: A similarity with the specimens of *Tristichella glabrescens* Iwats. from Baltic amber (Frahm, 2010: Figs. 120-121) was the main reason for referring the plant from Rovno amber to the genus.

Description: Stems >1 mm long, 80 μm wide, rather densely foliate. Leaves tristichous, erect-spreading, spreading since their base at 40-50° from stem, straight or gently curved inwards, 1.1-1.5 mm long, ca. 0.4 mm wide, ovate-lanceolate, gradually tapered to narrow acumen, concave-conduplicate; margin subentire; long single costa absent. Laminal cells in lower leaf linear, 80-110 μm long, 7-9 μm wide.

Specimen examined: Klesov. Rovno amber. Late Eocene. SIZK-K-6362 [syninclusions: Sciaridae (30m2f)].

Material: The species is represented by one short shoot, 1 mm long with ca. 15 leaves, but their arrangement in three rows is rather apparent, especially along a series of leaves broken in their lower parts (Fig. 32, above stem).

Comparison: Trifarious leaves make this species well recognizable from most other pleurocarps.

Unknown moss (Figs. 36-37).

Description: Stems >1 mm long; leaves polystichous. Leaves spreading at ca. 40°, 04-0.5×0.3 mm, ovate-triangular, abruptly short acuminate, concave; costa thin, percurrent. Areolation is not available for study.

Specimen examined: Klesov. Rovno amber. Late Eocene. SIZK-K-3606 [syninclusions: K-3605 worker of Formica flori Mayr (Formicidae); K-3606 Acari; K-3607 Ceratoppia (Acari)].

Material: Preservation is poor and the fragment does not permit more or less complete description. However it is obvious that the moss does not belong to any of the above described species. It has broad ovate-triangular concave leaves, abruptly short acuminate and having percurrent single costa. A small size and inconvenient position deeply inside amber make impossible a study of its areolation.

Comparison can be made with some small Amblystegiaceae (e.g., *Amblystegium*), Brachytheciaceae (e.g., *Microeurhynchium*), Pseudoleskeellaceae (e.g., *Pseudoleskeella*), etc. Among mosses from Baltic amber (Frahm, 2010), the most similar appearance probably have *Brachythecium tortifolium* J.-P Frahm (Frahm, 2010: Fig. 104) and *Sematophyllites planus* J.-P Frahm (Frahm, 2010: Fig. 115).

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